ELECTRO-OPTIC IDENTIFICATION SENSORS

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LONG TERM GOALS

The goal of the Electro-Optic Identification Sensors Project[1] is to develop and demonstrate high resolution underwater electro-optic (EO) imaging sensors, and associated image processing/analysis methods, for rapid visual identification of mines and mine-like contacts (MLCs). Identification of MLCs is a pressing Fleet need. During MCM operations, sonar contacts are classified as mine-like if they are sufficiently similar to signatures of mines. Each contact classified as mine-like must be identified as a mine or not a mine. During MCM operations in littoral areas, tens or even hundreds of MLCs must be identified. This time consuming identification process is performed by EOD divers or ROVs, and is the rate limiting step in many MCM operations. A method to provide rapid visual identification of MLCs would dramatically speed up such operations.

OBJECTIVES

We are at a transition point for the EOID Sensors project. The first generation EOID Sensor was developed by this project to support Surface MCM (SMCM), and is based upon Laser Line Scan (LLS) technology. LLS technology has consistently produced the best underwater image quality of any underwater imaging technology demonstrated to date. The EOID Sensor was successfully demonstrated to the Fleet at Combined Task Force Exercise 96 (CJTFEX96)[2], and has transitioned to the Advanced Sensors Joint Countermine ACTD program[3]. The successful demonstration of the capabilities of the EOID Sensor at CJTFEX96 has lead to fleet recommendations to field EOID Sensors to support both Air MCM (AMCM) and SMCM as soon as possible[4,5].

The current EOID Sensor is well suited to meeting the requirements of the SMCM identification system. The requirements on the AMCM identification system are more stringent. AMCM requires a higher tow speed (~10 knots) than SMCM (which can slow to ~4 knots for target identification.) The AMCM identification system must be able to operate in shallow water under high ambient light conditions. For SMCM systems this is highly desirable, but not required. Finally, AMCM places tighter size/weight requirements on the sensor. Accordingly, in this transition year the objectives of this project were refocused on development of a next generation EOID Sensor which will meet the AMCM requirements while giving improved performance for SMCM missions.

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ISSUES/APPROACH

The approach is to identify and understand the sensor performance and system design issues the new requirements impose. This will be followed by design and fabrication of the new sensor. Whenever possible, data acquired with existing LLS (and other) sensors is exploited to resolve the new issues. Additional image data in different environments is acquired when feasible, in order to extend our data base of underwater EO imagery. This includes use of the EOID Sensor and a prototype 4-channel LLS sensor.

The faster tow speeds required by AMCM indicate that the resolution required for identification should be reexamined. This is because increased tow speeds impact sensor performance through increased pixel sizes, increased scan and data rates, or both. The EOID Sensor was designed to image with ¼ inch pixels at tow speeds up to 4 knots. Quarter inch pixels have been demonstrated to be more than sufficient for target identification for MCM missions. At tow speeds of 10 knots, either the scan speed (and associated data rates) or the pixel size will increase by a factor of 2.5. The larger pixels may or may not be sufficient for target identification for MCM missions.

The EOID Sensor was designed to be tolerant of modest levels of ambient light noise, and will perform quite well in *some* environments even under high levels of ambient light noise. However, in turbid, very shallow water under high ambient light levels, the sensor performance degrades considerably. This issue must be addressed in order to provide a robust sensor to AMCM and SMCM.

Near real-time image processing, enhancement, and display of the image data is required to adequately support AMCM and SMCM. For both systems, large amounts of image data must be searched for mine-like contacts. Then the processed and enhanced images of only the mine-like contacts must be presented to an operator for target identification. For AMCM, this down-selection of the data to a small number of mine-like contacts for the operator to identify is important because the tow speeds are too fast for an operator to effectively deal with all the imagery. For SMCM in the Remote Minehunting System, this down-selection of the data is critical because the slow speed of the data link precludes transmission of any but a bare minimum of imagery.

The automatic selection of optically mine-like targets from background clutter is a challenging problem. One promising method of dealing with this problem is to exploit spectral information through use of a multiple channel LLS sensor. A key objective of the project is to investigate pay-offs associated with expanding the bandwidth of LLS systems to include spectral information.

WORK COMPLETED/RESULTS

The work completed in FY97 was largely directed to the image processing and enhancement issue. A database of LLS imagery from a variety of tests in a variety of

environments has been assembled. We are using this data base for development of image processing, image enhancement, and target detection algorithms to support the AMCM and SMCM requirements. This database contains approximately 100 images of mine-like contacts, clutter, and backgrounds. It is also available to qualified investigators[6]. A separate database of Fluorescence Imaging Laser Line Scan (FILLS), acquired using the prototype four-channel LLS sensor during CoBOP96, has been assembled and made available to CoBOP participants upon request[7].

Several algorithms for processing and enhancing LLS imagery have been developed[8,9,10]. These routines correct for channel to channel variations in the signal strength, compensate for the extended slant range on each side of the scan lines, and enhances low contrast objects obscured in low signal strength regions. Initially these algorithms required operator intervention for good results. They have been refined to be fully automated and adaptive, and will be demonstrated in near real-time in the Advanced Sensors ACTD[3]. Additionally, initial steps have been taken toward implementation of automated object detection algorithms.

The automated image enhancement routines have been extended to apply to the FILLS imagery acquired at CoBOP and other tests. A test report summarizing the 1996 testing of the prototype four channel LLS in its FILLS, polarization, and RGB-color modes is nearing completion[11]. An extended abstract describing this testing was published earlier[12].

Near the end of FY97, an opportunity arose to participate in a survey using the FILLS sensor in a new environment. The survey, sponsored by EPA and NOAA, was in Massachusetts Bay. It was conducted to survey several sites for effects of waste materials on the local ecosystem, and to search for potential missing waste barrels. This survey allowed us to extend our database of non-mine bottom objects (NOMBOS), and to obtain FILLS imagery in a moderately turbid environment. A quick-look report has been prepared[13].

A tank test was conducted using the EOID Sensor in order to establish its operational envelope. A series of targets were constructed which allow the detrimental affects of backscatter, blur/glow/forward scatter, and attenuation to be clearly identified and isolated. Consequently, when the imagery degrades to the point where an identification can no longer be made, it is possible to clearly identify the origin of this degradation (i.e., backscatter, forward scatter, or attenuation). Improved systems that address the identified limiting factor(s) can then be designed. This testing protocol will allow other underwater imaging sensors (e.g., laser range gated, and streak tube imaging lidar) to be similarly evaluated.

The EOID Sensors data base has been used to explore the resolution required for identification in clear and turbid water environments[14]. It indicates that typically ¼ inch resolution is not required for identifications to be performed.

In conjunction with the Raytheon, the prime contractor for the EOID Sensor, an ATD-99 proposal was prepared. This proposal, entitled "Rapid Airborne Mine Identification," was for a LLS sensor tailored for the AMCM mission. It incorporated a pulsed laser and a temporally gated receiver to address the ambient light issue. This proposal on one of only two ATD proposals which was rated by the Fleet CINCs as "Needed capability – Fund with high priority." The proposal made the cut to the final 10, but was not selected for funding.

IMPACT/APPLICATIONS

The demonstration of the EOID Sensor to the Fleet at CJTFEX96 allowed the Fleet to directly evaluate the impact of deployment of EOID Sensors on MCM operations. Fleet assessment was overwhelmingly positive, as expressed in Naval messages. The factor by which MCM operations would be accelerated through rapid visual identification with EOID Sensors was estimated in the first message. The second message includes the statement "(U) STRONGLY CONCUR WITH REF A RECOMMENDATION TO PROCEED WITH EOID PROGRAM AND FIELD EOID SYSTEMS ASAP" from COMINWARCOM.

TRANSITIONS

The Fleet has recommended immediate commencement of programs to field EOID Sensors as soon as possible. Deployment methods to support both Air MCM (AMCM) and Surface MCM (SMCM) have been requested. For AMCM , the EOID Sensor technology would be inserted into an AMCM tow body, such as the AN/AQS-14 or the AN/AQS-20, and deployed from a helicopter. This would allow identification of MLCs to proceed at AMCM speeds. To support SMCM, the EOID Sensor would be a part of the Remote Minehunting System (RMS) to allow rapid visual identification of MLCs detected and classified by the RMS sonars. This is very similar to what the EOID Sensor will demonstrate at the JCM ACTD in FY98.

Both of these deployment methods are technically quite feasible. Both would have significant operational pay-offs. RMS is a funded program that plans to include an EOID sensor type identification capability. A future AN/ASQ-XX airborne mine reconnaissance system will very likely include a similar EOID sensor type identification capability. EOID Sensor technology will transition to both programs. For both these systems, a full 24 hour/day operational imaging capability will be a requirement.

The EOID Sensor has transitioned to the JCM Advanced Sensors ACTD[3] for demonstration in FY98. It has also transitioned to the Mobile Underwater Debris Survey System[15] (MUDSS) Program, sponsored by the Strategic Environmental Research and Development Program (SERDP).

RELATED PROJECTS

This project is closely coordinated with the Coastal Benthic Optical Properties (CoBOP) DRI. This project is studying the optical signatures of backgrounds, clutter, and targets. These signatures are key to the development of the automatic target detection algorithms required to support AMCM and SMCM.

REFERENCES

1 . http://www.ncsc.navy.mil/CSS/Projects/eoid.htm.

2. McCormick, J., and M. Strand 1996: Quick Look Report, Electro-Optic Mine Identification Sensor Demonstration in Conjunction with CJTFEX 96, CSS/TR-96/49

3. http://www.onr.navy.mil/sci_tech/ocean/jcm/advsensr.htm

4. Naval message “How to speed up mine countermeasure (MCM) operations (U)” R140200Z May 96 COMCMRON TWO (C)

5. Naval message “How to speed up mine countermeasure (MCM) operations (U)” R041850Z Jun 96 COMINEWARCOM Corpus Christi TX (C).)

6. Contact Dr. Ed Linsenmeyer, CSS Code R052, 850-234-4161, linsenmeyer_ed@ccmail.ncsc.navy.mil.

7. Contact Mr. Andy Nevis, CSS Code R12, 850-235-5958, nevis_andy@ccmail.ncsc.navy.mil.

8. Nevis, A.J. 1996: Low Contrast Image Enhancement for Electro-Optic Data, CSS/TR-96/52

9. Nevis, A.J. 1997: Low Contrast Image Enhancement of Electro-Optic Data, SPIE Vol. 3079, pp 333-344. http://www.ncsc.navy.mil/CSS/papers/spie97lls.htm.

10. Nevis, A.J. 1997: Automated Image Enhancement for Laser Line Scan Data, CSS/TR-97/__.

11. Nevis, A.J., and M.P. Strand 1997: Imaging Laser Polarimeter (ILP) Test Report, CSS/TR-97/__.

12. Strand, M.P., B.W. Coles, A.J. Nevis, and R Regan 1996: Laser Line Scan Fluorescence and Multi-Spectral Imaging of Coral Reef Environments, SPIE Vol. 2963, pp 790-795. http://www.ncsc.navy.mil/CSS/Papers/oceanopeoid.htm.

13. Nevis, A.J., J.S. Taylor, and M.P. Strand 1997: Massachusetts Bay Survey Test Quick Look Report, CSS/TR-97/__

14. Nevis, A.J., and M.P. Strand 1997: EOID Resolution and Image Quality, CSS/TR-97/__.

15. http://www.ncsc.navy.mil/CSS/Projects/mudsstop.htm.